PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., April 1, 1916.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1915.

Respectfully,

D. W. MAY,
Agronomist in Charge.

DR. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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By D. W. May, *Agronomist in Charge.*

GENERAL CONDITIONS.

Of the 3,600 square miles of land in Porto Rico practically none is without growth of some sort. Nature abhors a barren soil. At the time of its discovery doubtless the entire island was covered with trees, as is now the area of virgin land in the highest mountains.

The utilization of the land in agriculture has proceeded in the same manner as in the States; that is, the more accessible lowlands have been cleared and planted, this area being successively extended through the foothills into the mountains. The cultivable area now may be divided into three general classes, (1) the lowlands devoted to sugar cane and grasses, (2) the hill lands formerly growing coffee but now exhausted for this crop, and (3) the mountain lands still planted to coffee but showing diminishing returns.

The lowlands are planted mainly to sugar cane with a rotation in grass. The period of resting depends upon the price of sugar, the tendency since the American occupation being to keep the lands in cane, using large amounts of fertilizer, deep plowing, and frequent cultivation to secure results that could be obtained by rotations with legumes.

Sugar production continues quite profitable, owing to good prices, large yields, and the employment of the most efficient machinery.

The coffee growers have had better prices but a smaller crop than usual during the year. While the European market has been largely shut off, there have been increasing sales to Cuba. Owing to the prosperity of that country, the people are using not only more but better grades of Porto Rican coffee. More favorable reciprocal trade relations covering coffee should be established with Cuba. Cuba could easily take the entire Porto Rican crop, as it is small and is the kind of coffee most relished by the Cubans.

The fruit crops have been good and better prices were received during the past season. There is a lessening of the area planted to fruit, but as a whole more attention is being given to the care of the plantings, resulting in larger yields and improved quality of fruit.

Cooperation has succeeded better among the fruit growers than among any other planters. They have an exchange for selling fruit

and buying fertilizers, boxes, etc., and community packing houses are being built wherever the extent of the plantings justifies their erection.

The fruit industry has grown up in the hill lands which had been cut over many years before and were not at the time very productive. It has required skill and money to develop this industry, which needs constant and unremitting care. It is the only special line of agriculture of any extent that has grown up under American development. The general good it has done to the island has been great. It has developed unproductive land, given employment to labor, increased the wealth of the country, and built up communities of beautiful homes and grounds in contrast with the desolation that had before prevailed.

The growth of agriculture in Porto Rico started in the coast lands and has been carried into the interior. As in the States when land became unproductive, operations were extended to new areas. In the States agriculture extended west from the Atlantic seaboard, while in Porto Rico it extended inland. This island, however, was settled before continental America, and the lands have been exploited for a much longer time. Moreover, there has been no emigration from Porto Rico, and while the lands showed diminishing returns the population continued to increase. It is from this condition that agriculture must now extricate itself.

The low-lying coast lands will continue to be profitable, the mountain lands planted to coffee will, with care, produce many more crops, but the intervening hill lands denuded of their forests, baked by the sun, and gullied by the rains, offer a most serious problem, for such soils, forming the larger part of the surface of Porto Rico, have not only lost their natural fertility, but do not respond readily to the application of plant food. They can be made again productive, but it will take time, and Porto Rican planters are not disposed to work for a remote profit. Legumes are the hope of such soils, and these should be followed with tree crops as assuring the greater profit and more certain returns. While such areas are basically good they yield the owner practically nothing, nor can they yield anything until a system of improvement covering a period of many years is persistently carried out. They were formerly planted to coffee, but the yields of this crop decreasing in the course of time to the point of unprofitableness, the leguminous shade trees were cut down and made into charcoal, and a condition of soil sterility followed as a natural consequence.

It is these large, unplanted areas that strike the stranger as unusual. They lead him to believe that the peons whose palm-thatched cottages are scattered about are shiftless to a high degree. This is partly true, but the condition is due more to ignorance than to laziness. These peons do not know how to make a quick crop grow, and

they are so destitute of the actual necessities of life that they can not consider the question of waiting for a crop which requires a long time to mature.

AGRICULTURAL LABOR.

While the natural resources of Porto Rico have decreased, the population has steadily increased until there are now 350 people to the square mile, making Porto Rico one of the most densely populated regions in the world. The problem, then, in agricultural endeavors, is to produce foodstuffs, or other crops of sufficient value to be exchanged for foodstuffs, for the maintenance of the ever-increasing population.

While the imports and exports of the island have grown, the general condition of the poorer classes has not changed in proportion. The population is increasing more rapidly than industries are developing, and, as a consequence, the standard of wages and living remains low. To arouse these people from the apathy of many generations is extremely difficult. There is little or no organization among them and competition for the lowest paid positions is keen.

It is the custom for the peons, as they are called, to build their houses on the plantation of the man for whom they work. These houses are of the crudest description, usually made of cheap boards, old packing boxes, and tin cans, with roofs of grass or leaves. They generally consist of two rooms and an outside kitchen, a table and a few chairs constituting the bulk of the furniture, the entire family usually sleeping on the floor. There is little improvement in their condition from year to year, as they have nothing to live upon but the labor which they offer in an overcrowded market. The plantations in the interior have as a rule more people living on them than they can support. These are employed for a few months in the cane fields but for the greater part of the year they are idle. If disaster overtake the cane crop the laborers must have outside aid or they starve.

With no coal or iron and little water power, manufactures have not generally flourished in Porto Rico, only cigar factories having been established on the island. Hat weaving and lace making give some employment to females. The maintenance of the people in this, one of the more densely populated countries of the world, must come mainly from agriculture.

Though there is growth throughout the year in Porto Rico, yet there are seasons when much labor is out of employment. These laborers, in order to maintain themselves during periods of idleness as well as to place themselves in a position to secure better pay, must become more independent of their daily wage. Many living in the country do not have gardens worthy of the name. and little, if any, live stock or poultry.

FERTILIZING ELEMENTS.

Where soils are depleted as are those of Porto Rico and where expenditures for fertilizers approximate $1,000,000 annually, it is advisable to seek all available sources of fertilizing elements. Phosphorus, potash, and especially nitrogen are lacking in most Porto Rican soils. The many leguminous trees and plants growing in the island are the principal source of the last element, but more recourse should be had to these plants in the system of agriculture. There are many deposits of phosphorus in caves located in the limestone regions and in Mona Island to the west. During the year, the station made extensive investigations of some of these deposits, and surveyed and mapped 103 caves in the island of Porto Rico. The caves on Mona Island have been worked at different periods for many years. At present these deposits are controlled by a company that pays to the insular government a ton royalty on the amounts extracted. Some has been used in Porto Rico, while considerable quantities have been shipped to the States. The experiment station has not yet investigated these deposits.

While these caves, like those in Mona Island, have deposits of sea bird guano, they are inhabited now only by bats. The caves are of three general classes, (1) those entered horizontally and apparently formed by separation of limestone strata, (2) sink holes (in one case 200 feet in depth) with galleries ranging from them, and (3) underground streams following natural cavities in the rock strata. They are situated in the limestone areas of the island, and vary greatly in size and extent, the largest being 450 feet deep by 90 feet wide. The deposits range from small amounts to more than a thousand tons, their physical condition differing as widely. Some are the unmodified droppings of bats, while others are caked and sometimes leached by rain water percolating through the roofs of the caverns.

Some of these deposits have already been partly used, especially where they are accessible to cane fields. While much of this fertilizing material is difficult to transport, yet it is of sufficient value to render its utilization less expensive than importation of fertilizers from other countries. The various deposits have been mapped and sampled, and further work, both analytical and cultural, will indicate their true value to Porto Rican agriculturists.

Owing to the European war it has been impossible during the year to obtain potash. The only available supply comes from tobacco stems and dust from the cigar factories. Some seaweed is deposited on the north coast during certain seasons but so far no use has been made of it as a source of potash.

On the south coast, which is almost rainless, large quantities of salt are obtained by the evaporation of sea water. The mother liquor drawn off after the sodium chlorid crystallizes out contains between

1 and 2 per cent of potassium chlorid. In southern France, where similar salt works occur, this mother liquor is used as a source of potash. On the southwest corner of the island, where salt making is now carried on, there are salt pans 150 acres in extent which are adjacent to similar land that could be utilized to increase the evaporating area tenfold.

In the manufacture of this salt the sea water is let into shallow basins during high tide by a gate at the coast line. After it is evaporated by the sun's rays to a certain concentration it is raised by windmills to the salt pans, where, after further evaporation, the salt crystallizes out. The mother liquor is then run back into the sea at low tide. The present capacity of the salt pans is about 30,000 tons of salt annually. From the by-product, the mother liquor which is thrown away, it is estimated that 1,000 tons of potassium could be recovered. This matter will be further studied, with a view to determining the feasibility of profitably using this by-product.

LIVE STOCK.

There has been a great improvement in all classes of live stock during the last few years, but there is yet much to be desired in this industry. Owing to a change in the regulations covering the use of funds from sales, the activities of the station in stock breeding have been curtailed. Cattle breeding is the only line now followed, the other stock having been disposed of. Now that there are breeders of the several lines of improved live stock it is not so difficult for those desiring pure-bred animals to secure them. In the past horse breeding has received the most attention, but now dairy stock is in great demand and cattle growing is profitable.

The island produces most excellent grasses. Corn and the non-saccharin sorghums are grown. Sudan grass, a recent introduction, is very successful on the south, or dry, side of Porto Rico, and its production is increasing rapidly. The velvet bean, while improving the soil, is also finding favor as a stock feed. Not the least of the activities of the station is the growing and distribution of these forage crops.

The cattle tick prevails throughout the island and is the greatest drawback to cattle growing. Its extermination is necessary, and could be accomplished at comparatively small expense. When public sentiment becomes aroused to the desirability of getting rid of this pest it will no doubt be eliminated.

Among the poorer classes goats are used for producing milk. Their cost is small and they subsist on the scantiest herbage. They are destructive, however, to tree growth. Cattle, when they can be afforded, lend themselves to the permanent development of the country.

FORESTRY.

The reforesting of the 200 acres set aside by the insular government on the mountain above Mayaguez has been continued by the setting of many more trees, among the more promising of which are mahogany, mango, and mamey. This tract has been bare of trees for some years and is badly washed. As it had been used as public land it was unfenced and closely grazed, and along the gullies where trees had grown best they had been cut and used by charcoal burners.

A great many trees have been propagated and sent out by the experiment station during the year. The most popular have been improved varieties of mango, mahogany, and eucalyptus, also many leguminous trees, both native and foreign.

There is in Porto Rico practically no soil that is not producing some form of plant life. It is the desire of the station to make the land produce the maximum of crops supplying the necessities and comforts of life. Soils growing only sparse grasses or worthless plants should be made to grow valuable crops. Trees having the greatest area of bearing surface will give the greatest returns per acre, and with a dense population it is necessary to use only those producing such returns. The hill lands, much of which does not yield profitable annual crops, should be planted to trees, preferably legumes, as the land so planted will yield more forage than is now obtained from the scanty herbage left by the baking sun and beating rains, while these trees will at the same time act as nurse trees for the more profitable coffee, cacao, and fruits.

COOPERATION.

The detailed work of the station is given under the reports of the various departments. Better facilities are greatly needed for bringing results to the planters, especially through cooperation with the agricultural college and the public schools. In conference, by correspondence, and through the distribution of seeds and plants cooperation is being furthered, but much more work along this line is highly desirable.

Cooperation with the insular government in the production of fiber crops, especially the weaving palms, is being continued. A plan of cooperation has been adopted whereby there is a division of labor and mutual helpfulness between this station and the insular station at Rio Piedras. The Bureau of Plant Industry, United States Department of Agriculture, has been of assistance in introducing various seeds and plants, many of which are proving valuable additions to the cultivated crops. Some of the more progressive planters are growing experimental plats of these introductions, which serve not only as tests of their value, but also as demonstrations to the farmers of the neighborhoods.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

INTRODUCTION.

No new problems were taken up the past year, those mentioned in the previous report demanding all the time and facilities available. Satisfactory progress was made in most of the investigations, and some will be completed soon. The fertilized plats of sugar cane on the red-clay soil were cut the past year, and the results of the tests are reported below.

ANALYTICAL WORK.

All the analytical work was devoted to the various investigations mentioned. The analysis of some 50 samples of plant ashes and 200 samples of guano constituted the larger part of this work, although a number of miscellaneous samples were analyzed and many determinations were made of the soluble iron in various nutrient solutions.

BAT GUANOS.

Considerable progress was made in the study of bat-guano deposits, and it is expected that the work will be virtually completed by the end of 1916.

Some 200 samples of guano were analyzed for nitrogen and the three forms of phosphoric acid. Seventy-five of these were tested once or several times in experiments with corn and millet to determine the availability of the phosphoric acid for plants. This gave a check on the availability of the phosphoric acid as determined by the solubility in neutral ammonium citrate. Some experiments were also conducted to determine the effect of different soils on the availability of the guanos as compared with acid phosphate, bone meal, and basic slag.

The results of the work thus far confirm the notes on guanos published in the previous annual reports and bring out some new facts.

The greater part of the guanos are to be considered as low grade phosphatic fertilizers; that is, they have to be used in considerable quantities to give the same results as acid phosphate or basic slag.

The percentages of total phosphoric acid found in the samples analyzed thus far range from 1 to 42 per cent. The samples containing very high percentages of total phosphoric acid generally contain

little that is available, although this is not an absolute rule, as a few samples from the drier caves contain a high percentage of total phosphoric acid with more than half soluble in neutral ammonium citrate. By vegetation tests it appears that if the availability or effectiveness of the phosphoric acid in acid phosphate is taken as 100 per cent, the effectiveness of the phosphoric acid in different guanos ranges from zero to 100 per cent. With most guanos the solubility of the phosphoric acid in neutral ammonium citrate parallels very closely its availability as determined by vegetation tests with corn and millet. As phosphatic fertilizers the guanos are equally effective for corn and millet.

Most of the deposits contain but little nitrogen, although there is a small amount of material in nearly every cave, generally the first 2 to 3 inches of the deposits, that contains considerable nitrogen. The very fresh material that has undergone no decomposition may contain 10 to 11 per cent of nitrogen. The percentage of nitrogen generally decreases with the age of the deposit, or rather with the rapidity of the bacterial decomposition. A few deposits, however, have been examined that contain considerable nitrogen and yet, from their depth and extent, they must be of considerable age. These deposits, which are very wet, have probably undergone an anaerobic bacterial decomposition similar to that which results in the formation of peat. It is probable that the availability of the nitrogen in this particular class of guanos is low.

LIME-INDUCED CHLOROSIS.

As mentioned in the preceding report, it has been necessary to investigate several general or subsidiary problems before analytical and other data secured in the direct study of chlorotic plants could be properly interpreted. One of these investigations on the variation of the ash composition of rice at different stages of growth was completed and published.[1] Some of the results brought out follow:

From the analyses of withered and green parts of normal rice plants at various stages of growth, it appears that there is a regular and marked decrease in the iron content of the green straw and leaves with the increasing age of the plant. The withered straw and leaves, however, contain higher percentages of iron than the green, so that there is little variation in the percentage of iron in the ash of the whole plant after the twenty-sixth day. It is, therefore, important in making comparative iron analyses of green and chlorotic plants, where only live or functioning leaves and straw are sampled, to take into account the relative development or maturity of the plants.

[1] U. S. Dept. Agr., Jour. Agr. Research, 5 (1915), No. 9, pp. 357–364.

Data were also obtained on the other ash constituents, which are of less importance in the study of chlorosis. The percentages of potash, phosphoric acid, and sulphur in the ash, and of nitrogen in the dry matter decreased with the age of the plant, while silica increased. Compared with the plant at the time of flowering, the mature plant with seeds ripe contained practically the same absolute amount of all ash constituents except potash, which increased, and soda, which decreased. Previous to flowering, the percentages of dry matter in the green plant and of ash in the dry matter seem to be influenced by the effect of the weather on the growth of the plant.

A second accessory investigation of chlorosis was nearly completed the past year, consisting of a study of the assimilation of iron by rice from several nutrient solutions, using a number of different iron compounds in varying quantities. This will probably throw some light on the available forms of iron and on the factors affecting their assimilation.

A third investigation on the extent to which roots can exercise the power of selective absorption will probably be completed the coming year, satisfactory progress having been made.

RECOMMENDATION FOR FUTURE WORK.

With the installation last year of equipment for conducting vegetation experiments in pots, facilities are now adequate for carrying on certain lines of work on soils, fertilizers, and plant nutrition. The laboratory is also fairly well equipped for handling the analyses necessary to such studies. Probably the most profitable extension of the work would be a systematic soil survey combined with field experiments.

The need of a soil survey and a comprehensive series of fertilizer experiments on the different soil types is more or less patent to all familiar with conditions on the island. The great variety of Porto Rican soils, with the wide variations in rainfall, makes proper fertilization a very complex problem. Thus far the fertilizer requirements of the red clay soil for sugar cane, and of certain sandy soils for citrus trees, have been fairly well determined in certain districts, but this is only a very small beginning. In many localities even basic questions, such as what fertilizing elements the soils need, have not been decided, and secondary problems of fertilization, such as the quantity and form in which the elements should be applied, have not been approached.

Many data, some unpublished, have already been accumulated on the area and chemical composition of the different soils. Such data, however, are not of great value unless accompanied by data of field experiments.

FERTILIZER EXPERIMENTS WITH SUGAR CANE ON THE RED-CLAY SOIL.

INTRODUCTION.

In continuation of investigations previously reported,[1] further fertilizer experiments with sugar cane have been conducted on the red-clay soil. It seems advisable to report the results of these subsequent tests, as there is no opportunity for continuing this work at present.

The experiments previously reported showed that much of the red-clay soil planted to sugar cane did not respond appreciably to fertilizers or the usual soil amendments, while some other areas did respond to fertilizers and to lime. The work detailed below was undertaken to determine the fertilizer requirements of those areas benefited by fertilization. Specifically, the following tests were designed to show what fertilizing element or elements were effective, and to compare the relative effectiveness of different nitrogenous fertilizers, since in the previous tests nitrogen was the only element that appreciably increased the yield.

In this work it was desired to measure whatever increases might be produced by the different fertilizers with considerable accuracy so that the profit or loss could be calculated. To secure this accuracy, each differently treated tenth-acre plat was replicated eight times in each experiment, and in the experiment where half-acre plats were used, the treatments were repeated at least seven times. The field plats were all located in different part of the Anasco Valley on land controlled by the Guanica Central. This company furnished the fertilizers and facilities for conducting the tests.

RESULTS OF FERTILIZER TESTS.

EXPERIMENT AT HACIENDA TRINIDAD.

This experiment, in which the tests were replicated from 7 to 14 times, comprised 73 plats of one-half acre each. It was designed to show the needs of the soil for lime and the fertilizing elements, and to compare the effectiveness of dried blood and ammonium sulphate with sodium nitrate.

The soil was a deep, brownish-black clay, not the distinctive red-clay soil, but more nearly related to this type than any other. The field was low, and during excessive and long continued rains was sometimes flooded. As it was irregularly shaped, it was impossible to arrange the plats in any regular succession, but the replicated plats were all widely separated. The field had been in pasture for 16 months following sugar cane and was considered ordinarily productive land for the district.

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[1] Porto Rico Sta. Bul. 14 (1914).

Thirty-five hundred pounds of quicklime per acre was applied to certain plats in the first part of February, 1913, and the field was then plowed with a steam plow to a depth of 14 inches. Rayada cane, mixed with Cristalina, was planted in the latter part of March, 1913. Fertilizers were applied in the furrow from June 2 to June 5. The cane was cut the last of March and first of April, 1914.

Phosphoric acid and potash, both applied at the rate of 50 pounds per acre, were derived from double superphosphate and high-grade potassium sulphate. For a comparison of the different forms of nitrogen, sodium nitrate was applied to furnish 50 or 30 pounds of nitrogen per acre, while ammonium sulphate and dried blood were applied in amounts to furnish 30 pounds of nitrogen per acre. As previous tests had shown that the land in this district responded well to nitrogen alone, the plats in this test used for a comparison of the different forms of nitrogen received either sodium nitrate, dried blood, or ammonium sulphate without potash or phosphoric acid.

The cane germinated well and made a good growth for the short growing season, but at no time could any regular differences be seen between the differently treated plats.

In Table 1 are given the maximum, minimum, and average yields of the different plats.

TABLE 1.—*Results of fertilizer experiments at Hacienda Trinidad.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain (+) or loss (−).
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	14	34.3	17.3	25.6	.....
Lime, 3,500 pounds	8	33.6	17.7	26.3	+0.7
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; potash, 50 pounds	7	33.1	27.5	30.7	+5.1
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; potash, 50 pounds; lime, 3,500 pounds	8	35.1	15.3	26.5	+0.9
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; lime, 3,500 pounds	8	33.6	16.9	25.0	−0.6
Nitrogen (from sodium nitrate), 50 pounds; lime, 3,500 pounds	7	35.5	16.2	24.5	−1.1
Nitrogen (from sodium nitrate), 30 pounds; lime, 3,500 pounds	7	35.9	20.8	27.1	+1.5
Nitrogen (from ammonium sulphate), 30 pounds; lime, 3,500 pounds	7	34.4	16.1	24.2	−1.4
Nitrogen (from dried blood), 30 pounds; lime, 3,500 pounds	7	34.2	17.3	25.8	+0.2

After cutting the cane it became evident that the field varied greatly in productivity, four strips across the field being especially unproductive. It was impossible to correlate the low yield of these strips with any differences in elevation of the land, in drainage, or in appearance of the soil. The high average yield of the complete fertilizer plats without lime is doubtless due to an error in that none

of these plats were located in these unproductive strips. Bearing this in mind, it is clear from the table that 3,500 pounds of lime per acre, with or without a complete fertilizer, did not affect the yield nor did any of the incomplete fertilizers nor any of the three forms of nitrogen. A comparison of individual plats in different parts of the field showed that, in all parts of the field, in the more productive as well as in the less productive areas, plats treated with lime and various fertilizers gave no more cane than untreated check plats.

EXPERIMENT AT HACIENDA ALTAGRACIA, FIELD 3.

This experiment, comprising 70 plats of one-tenth acre each, with all tests repeated at least eight times, was designed to determine on this soil the relative needs of sugar cane for nitrogen, phosphoric acid, and potash, singly and in combination.

The soil was typical, stiff, lowland red clay, brownish-red in color, and quite uniform for a considerable depth, the subsoil at 1 foot being only a little lighter in color than the surface soil. The field appeared exceptionally uniform in respect to drainage and character of the soil, and was considered of average productivity. It had been in cane for several years continuously, and previous to that had been left in pasture about every third year.

The land was plowed with a steam plow to a depth of about 2 feet early in April, 1914, and Rayada cane mixed with some Cristalina was planted the latter part of the same month. Fertilizers were applied in the furrow June 25, 1914. Cane was cut April 23 and 24, 1915. The fertilizers were all applied in sufficient quantity to furnish 50 pounds of each element (nitrogen, phosphoric acid, and potash) per acre. Ammonium sulphate was used as the source of nitrogen, double superphosphate as the source of phosphoric acid, and high-grade muriate of potash as the source of potash.

The cane germinated well and grew normally. Three months after the application of the fertilizer all the plats receiving nitrogen alone or in combination with the other elements looked quite a little better than the others.

In Table 2 are given the data on the treatment and yields of the various plats.

TABLE 2.—*Results of fertilizer experiments at Hacienda Altagracia, field 3.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain (+) or loss (−).
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	13	24.1	17.0	18.9	.....
Nitrogen, 50 pounds	8	27.1	20.2	22.5	+3.6
Phosphoric acid, 50 pounds	8	22.0	15.1	18.8	−0.1
Potash, 50 pounds	8	21.3	17.2	19.4	+0.5
Nitrogen, 50 pounds; phosphoric acid, 50 pounds	8	25.3	18.4	22.3	+3.4
Nitrogen, 50 pounds; potash, 50 pounds	8	25.0	20.0	22.4	+3.5
Potash, 50 pounds; phosphoric acid, 50 pounds	8	24.0	16.0	19.5	+0.6
Nitrogen, 50 pounds; potash, 50 pounds; phosphoric acid, 50 pounds	8	24.5	21.0	22.8	+3.9

The weights of the yield of the individual plats showed that this field was exceptionally uniform in productivity for this class of soil, especially the part covered by the first 50 plats, the part covered by the last two rows of plats being about 20 per cent more productive than the rest of the field. The greater productivity of this portion of the field did not appreciably affect the average results, however, as the plats were well distributed over the field.

The average yields of the differently treated plats show, with a uniformity which indicates the reliability of this test, that nitrogen was the only element that appreciably increased the yield of sugar cane on this soil. The plats which received nitrogen alone or in combination with potash or phosphoric acid, gave an increase over the unfertilized plats of about $3\frac{1}{2}$ tons of cane per acre. Potash and phosphoric acid, alone or in combination, produced no increase of yield exceeding the probable error of the average weights. That nitrogen was the only fertilizing element affecting the yield is further substantiated by the uniformity of the increases produced by the mixtures carrying nitrogen, nitrogen alone giving an increase of 3.6 tons of cane per acre, while the increases produced by nitrogen plus potash, phosphoric acid, or both, did not vary significantly from 3.6 tons.

An increased yield of $3\frac{1}{2}$ tons of cane due to an application of 250 pounds of ammonium sulphate (furnishing 50 pounds of nitrogen) is not sufficient to make the application profitable in all years. The cost of the fertilizer and of its application was about $11. Cane would thus have to net the planter more than $3.10 per ton,[1] or the fertilizer would have to produce a greater increase than $3\frac{1}{2}$ tons per acre to make the application profitable.

[1] It is assumed that a ton of cane nets the planter its price at the mill minus the cost of cutting and transportation. In this particular case, cutting and transportation cost about $1.30 per ton. Hence, with cane selling better than $4.50 per ton at the mill, the fertilization would have been profitable.

EXPERIMENT AT HACIENDA ALTAGRACIA, FIELD 19.

An experiment which included 72 plats of one-tenth acre each, with each method of treatment repeated 8 times or more, was a duplicate of the preceding test in Altagracia field 3 in respect to plan and to kind and quantity of fertilizers applied. The field is very similar to the preceding one in respect to soil, but probably slightly inferior in drainage, as it is located nearer the sea and a few feet lower. The soil is very uniform, but some parts of the field vary possibly 2 or 3 feet in elevation and consequently in drainage. It had been continuously in cane for 3 or 4 years, but previous to that was left in pasture about every third year. In regard to productivity, it was considered slightly superior to the preceding field.

The land was plowed with a steam plow to a depth of 2 feet the first of December, 1913. Rayada cane mixed with some Cristalina was planted the last of December and first of January. The cane germinated rather poorly during the dry weather and was partially replanted the last of January. Fertilizers were applied in the furrow February 17, 1914, and the cane was cut January 7 to 13, 1915.

No regular differences between the differently fertilized plats could be distinguished at any time, although there were marked differences between individual plats, apparently due to variations in drainage.

Data on the treatment and yields of the various plats are given in Table 3.

The yields of similarly treated plats varied much more in this test than in the preceding, while the differences due to fertilizers were smaller. It is evident that none of the fertilizing elements used alone or in combination measurably increased the yield. The slight increases attributable to the fertilizers indicate that nitrogen is relatively the most necessary element, although this is uncertain. The results show plainly that the yield of cane on this soil is limited by some factor other than the supply of plant food, and that application of fertilizers this year was made at a loss.

TABLE 3.—*Results of fertilizer experiments at Hacienda Altagracia, field 19.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain.
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	15	29.3	12.7	20.8	.....
Nitrogen, 50 pounds	8	26.2	20.7	23.2	2.4
Phosphoric acid, 50 pounds	7	25.6	11.4	20.8	0.0
Potash, 50 pounds	8	29.4	19.2	22.0	1.2
Nitrogen, 50 pounds; phosphoric acid, 50 pounds	8	28.6	17.2	22.4	1.6
Nitrogen, 50 pounds; potash, 50 pounds	8	27.5	18.5	22.6	1.8
Potash, 50 pounds; phosphoric acid, 50 pounds	8	29.4	15.7	22.6	1.8
Nitrogen, 50 pounds; potash, 50 pounds; phosphoric acid, 50 pounds	8	30.4	15.4	23.3	2.5

EXPERIMENT AT HACIENDA CIPRIANO, FIELD 19.

This experiment was planned to determine the relative effectiveness of four different fertilizers furnishing nitrogen, namely, ammonium sulphate, sodium nitrate, tankage, and cyanamid. It comprised 75 plats of one-tenth acre each, with all tests repeated at least 8 times.

The soil was the usual red clay, somewhat brighter red in color than that of the fields described in the two preceding experiments, and the elevation of this field, though slight, was greater than that of the two preceding fields. The field had been in pasture for one year, and in previous years had been in cane about two-thirds of the time. The last crop of first ratoons on this land was very poor.

The land was plowed with a steam plow in December, 1913, and planted in January, 1914, with mixed Rayada and Cristalina cane. Germination was poor during the dry weather and some replanting was done later. Fertilizers were applied in the furrow on February 28, 1914. Potash and phosphoric acid were derived, respectively, from high-grade muriate of potash and from double superphosphate.

In June small differences were observed in favor of the plats receiving nitrogen. The cane was cut the last of February and first of March, 1915.

Table 4 shows the fertilizers applied to the various plats and the yields of cane obtained.

TABLE 4.—*Comparison of tests of different nitrogenous fertilizers at Hacienda Cipriano, field 19.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain.
		Tons.	*Tons.*	*Tons.*	*Tons.*
No fertilizer	15	22.8	12.9	18.8	.....
Check, potash, 75 pounds; phosphoric acid, 50 pounds	8	21.4	15.8	19.3	.....
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 20 pounds	7	21.6	19.2	20.3	1.0
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 35 pounds	8	23.9	16.9	21.7	2.4
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 60 pounds	8	27.4	22.8	25.0	5.7
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from sodium nitrate), 35 pounds	8	24.5	15.7	21.6	2.3
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from tankage), 35 pounds	8	24.7	18.4	22.3	3.0
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from cyanamid), 35 pounds	8	26.0	19.5	23.4	4.1

The yields of the 15 check plats show the variation in productivity of the unfertilized field. The yields of the ammonium sulphate plats compared with those of plats receiving only potash and phosphoric acid give data showing the increase in tons of cane due to application of 20, 35, and 60 pounds of nitrogen from ammonium

sulphate. These data show what increases would have been produced by all amounts of nitrogen below 60 pounds, and from the figures it can be determined what quantities of ammonium sulphate would have been required to produce the same increases as those actually produced by 35 pounds of nitrogen from sodium nitrate, tankage, or cyanamid. A comparison of these quantities gives the effectiveness of the different forms of nitrogen relative to ammonium sulphate.

As it is evident that 35 pounds of nitrogen from sodium nitrate gave the same increase as 35 pounds of nitrogen from ammonium sulphate, the effectiveness of these two forms of nitrogen was therefore equal. Tankage, however, gave a slightly greater, and cyanamid a markedly greater, increase than the equivalent amount of ammonium sulphate. On the other hand, it appears that 39 pounds of nitrogen from ammonium sulphate would have been required to produce the same yield as that produced by 35 pounds of nitrogen from tankage, while 47 pounds of nitrogen from ammonium sulphate would have been needed to equal the 4.1-ton increase produced by cyanamid. The effectiveness of tankage and cyanamid as compared with ammonium sulphate may be expressed as $\frac{39}{35}$ and $\frac{47}{35}$ respectively. Calling that of ammonium sulphate 100, the effectiveness of sodium nitrate was 100, that of tankage 111, and that of cyanamid 134.[1]

In this test potash and phosphoric acid were applied to all plats to ensure the success of the experiment, hence these results do not show that nitrogen was the only necessary element for cane on this soil. The results do show, however, that nitrogen was one, if not the only, fertilizing element needed. In this test the larger applications of nitrogen were more effective than the smaller, but this would probably not be the case in all years. These data, combined with those of previous experiments, show that 50 pounds of nitrogen per acre is not too much to apply, and that on some of the red-clay soil this application will yield a profit.

DISCUSSION OF RESULTS.

In two of the experiments just described fertilizers were without effect on the yield of plant cane, in a third test they produced a measurable increase, and in a fourth test a marked increase. These results emphasize the point made in the previous report that the application of fertilizers to the red-clay soil is not always productive of results. Including the experiments noted here, those reported in a previous publication[2] of this station, and those reported by the Insular Experiment Station, the results of some 16 field ex-

[1] The advantages of this method for calculating the relative effectiveness of different fertilizers have been noted elsewhere. Gile, P. L., Jour. Amer. Soc. Agron., 6 (1914), No. 1, p. 36.

[2] Porto Rico Sta. Bul. 9 (1910).

periments with fertilizers on the red-clay soil at Hormigueros, Mayaguez, Anasco, and Rio Piedras are now available. In only 7 or 8 of these tests did fertilizers produce a measurable or marked increase in plant cane.

From these tests no rule is apparent for predicting just what areas of red-clay soil it will pay to fertilize. The previous history of the land, with regard to the time it has been in cultivation, is evidently not a safe guide. Probably the better-drained areas of brighter red soil are more likely to respond to fertilizers than other areas. Poor drainage with its secondary effects undoubtedly limits the productivity of many areas much more than the supply of plant food.

In the above tests, where the land responded to fertilizers at all, nitrogen appeared the only essential element, as nitrogen alone produced as great an increase as any of the incomplete mixtures containing nitrogen or as the complete fertilizer. That nitrogen is probably the only necessary fertilizing element for sugar cane on the red-clay soil is shown not only by the tests reported here and those given elsewhere [1] but by the test reported by the Insular Experiment Station at Rio Piedras.[2]

As to the best nitrogenous fertilizer for this soil, the test in Hacienda Cipriano seems to show cyanamid as considerably superior to either sodium nitrate, tankage, or ammonium sulphate, the latter three forms being very nearly alike.[3] It should be borne in mind, however, that while the test in Cipriano is about as accurate as can be obtained by field experiment, it is only a single trial with plant cane. Ratoon cane on this soil might have responded better to one of the other nitrogenous fertilizers. Also a slight error in the average weights of cane in this test, due to the soil of one lot of replicated plats averaging slightly better than that of another lot of plats, would have materially affected the results. It is, therefore, felt that while the test with the different forms of nitrogen is fairly reliable, it will not be conclusive until supported by further tests on this soil.

SUMMARY.

The results of four experiments on the effect of fertilizers on sugar cane on the lowland red-clay soil, involving 290 plats and 58 acres of land, show that one field failed to respond to 3,500 pounds of quicklime per acre with and without various commercial fertilizers; on another field all combinations of nitrogen, phosphoric acid, and

[1] Porto Rico Sta. Bul. 14 (1914).

[2] Rpt. Bd. Comrs. Agr. Porto Rico, 3 (1913–14), p. 56.

[3] On the basis of money values, cyanamid would have been far superior to the other forms, a pound of nitrogen in cyanamid being cheaper than a pound of nitrogen in the other materials.

potash applied at the rate of 50 pounds of each element per acre were ineffective; and on two other fields fertilizers measurably increased the yield.

Where the land responded to fertilizers, nitrogen was the only essential element.

As to the value of the different nitrogenous fertilizers for sugar cane on this soil, a single test with plant cane showed that, calling the effectiveness of ammonium sulphate 100, that of sodium nitrate was 100, that of tankage 111, and that of cyanamid 134.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

COCONUTS.

During the past year an experiment on the fertilization of young coconut palms was undertaken on the plantation of A. J. Harvey, about 4 miles east of the city of San Juan. The area devoted to the experiments lies about a half mile inland and is a level plain a few feet above sea level. The soil is a light but apparently fertile sandy loam which seems well adapted to coconut culture. Plats of 10 trees each have received two applications of fertilizers and one application is to be made every six months until the experiments are concluded. Tests are being made with complete and incomplete mixtures of chemical fertilizers, also with tobacco stems, stable manure, and seaweed in combination with chemical mixtures. It is planned to carry on this work for a number of years as there is a great demand for information regarding the needs of young palms, due to the development of commercial groves on the island wherever the soil conditions are suitable. The results from these tests will be a valuable supplement to those obtained in the work with older bearing palms which has been in progress for a number of years.

The experiments in fertilizing bearing coconut palms undertaken in 1912 are being continued and are giving valuable results. While the application of fertilizers resulted in but little increase in the yield of nuts during the first two years in which the experiments were in progress, marked gains in yields have been recorded during the past year for plats given a complete fertilizer; that is, a mixture containing 6 per cent nitrogen, 8 per cent phosphoric acid, and 12 per cent potash. Where 10 pounds per tree was applied, a gain of over 30 per cent in yield of nuts per tree over the check plat was obtained, and where 20 pounds per tree of the same material was applied, a gain of nearly 60 per cent was noted. Where nitrogen or potash was omitted from the mixture, no increase in yield was recorded, and where phosphate was omitted, there was only a slight increase. The average diameter of nuts harvested from the different plats has varied little since the experiments were first undertaken.

The record of the individual yield of the 350 palms under observation shows that many of them are so unproductive that they are being cared for at an expense and should be removed to provide a larger area for more productive ones or to be replaced by young, thrifty plants. In this field exceptionally productive individuals are no more numerous than exceptionally unproductive ones, and those giving poor yields are as plentiful as those giving good yields. This condition no doubt exists in every part of Porto Rico where coconuts are grown, and every owner should make a thorough canvass to determine the production of his individual palms.

MANGO.

Thirteen varieties of the imported mangoes in the station orchard fruited this year, including Cambodiana, Alphonse, Totafari (Pl. I, fig. 1), Sandersha, Amini, Mulgoba, Bulbulchasm, Davis Favorite, Divine, Sufaida, Paheri, San Pareille, and Martinique. The first three and the last two mentioned were much more prolific than the others, and the first three were the most satisfactory from the standpoint of the commercial planter. The variety Cambodiana has for several seasons seemed the most promising variety for home planting in Porto Rico, as the trees are thrifty, prolific, and regular bearers, and the fruit is first class in texture, flavor, and appearance. As the skin of this fruit is tender, it would probably be less satisfactory for shipping than some other varieties. The fruit of the variety Alphonse, or Bennet, was promising for commercial use this year. The trees bore their first crop when 8 years old. The fruits were of good appearance, flavor, and size, weighing about 14 ounces, the texture of the skins indicating that they would be valuable for shipping (Pl. I, fig. 2). Trees of the variety Amini, which in former years gave promise as a variety for general planting, as they came into bearing early and were prolific in fruit of good size and appearance, gave a small crop this year, and the fruits were too small to be satisfactory for commercial use. Sandersha, a variety suitable for use in making preserves or chutney, as in other years was the most prolific variety. San Pareille and Martinique have proved unsatisfactory for planting. The trees and fruits of these varieties are very similar. The trees are small and very slow-growing, and the fruit, while of good size, is very unattractive in color and unpleasant in taste, with a strong, disagreeable odor when entirely ripe.

In connection with the work with imported varieties, notes have been made on the quality of fruit and seedling growth of different wild types. These uncultivated varieties, found in abundance, are inferior in almost every way to the imported East Indian varieties. The fruits, while pleasant in flavor, are fibrous, undersized, and large

seeded, and the seedling trees grow much more slowly than the introduced types, and are therefore less satisfactory for use in grafting and inarching. The slower growth of the wild types is accounted for, partly, at least, by the fact that several plants spring from the same seed and soon exhaust the nourishment, while but one or two plants germinate in a seed of the imported kinds thus far tested. Fruits of imported varieties keep much longer in both cold and common storage than do the wild Porto Rican kinds. Fruits of the former, when allowed to become fully ripe on the tree and then placed in a cold room at 40° to 44° F. were in marketable condition from two to four weeks later, depending upon the variety, while the native kinds given the same treatment had large darkened areas in the skin, rendering them unsalable in from 8 to 12 days.

As the seed covering is very thick and tough in all the common Porto Rican mangoes, tests were made to determine the effect of opening and of removing this covering before planting. Several hundred seed were tested, and it was found that seeds removed from the husk before planting gave far better germinations than those whose husks were opened on one side only, and those opened on one side gave better results than seeds planted just as they were taken from the fruit.

VEGETABLES.

Tests started in 1910 to determine the influence of the Porto Rican conditions on northern varieties of vegetables, when introduced and grown here for a number of consecutive years, were concluded during the past year. Forty plantings (including eight generations) of beans were made with no indications that the later plantings were inferior to the earlier ones. As with all other vegetables under observation, the yield was greatly influenced by the season at which the planting was made. All plantings of beans made in March gave excellent results, while poor yields were realized from June, September, November, December, and January plantings. Okra was grown through eight generations in Porto Rico also, with no indications that the tropical conditions caused any degeneration of the crop. Yields from summer and fall plantings were not sufficiently large to make okra profitable as a commercial garden crop, while winter and early spring plantings produced well. Late summer and fall plantings of tomatoes produced well, while yields from late winter and spring plantings were small. With tomatoes as with other crops, yields in number and size of fruits produced per plant were uniform for all generations grown side by side. Fall plantings always produced abundantly, while the yields from late winter and spring plantings were small.

There is a popular belief in Porto Rico that garden crops brought here from the North degenerate from generation to generation and that seed produced in Porto Rico from these plants can not be depended upon for a satisfactory return. This belief is accounted for partly by the poor harvests from plantings made at unfavorable seasons and partly by the fact that seed lose their viability quickly when exposed to the moist air of Porto Rico, and therefore germinate poorly if stored from one harvest until the next favorable season for planting, which, with most vegetables, is several months, at least on the western end of the island, where the experiments were conducted.

A device employed for preserving the viability of seed during the progress of the experiments was so satisfactory that it is recommended for general use. It consisted of air-tight glass jars in the bottom of which had been placed a few ounces of calcium chlorid. This material was covered with a screen and the jar filled with cloth bags of seed. As the value of the chemical used in this way is in its ability to take up moisture from the air, care must be taken that the jars are kept tightly covered. Metal or glazed earthenware vessels will do as well as glass if kept air-tight.

The results of this work should prove valuable in changing the belief that seed deteriorates in the Tropics and in inducing gardeners of different localities of the island to conduct experiments to determine the best season for planting vegetables and to keep their seed from open air.

A report of these experiments has been prepared for publication as a bulletin of this station.[1]

MISCELLANEOUS INTRODUCTIONS.

Smooth Cayenne pineapple.—Plants sent from the Hawaiian Islands in 1914 arrived at the experiment station in good condition. They have all lived, but at one and a half years from planting are but little larger than when first planted. They were planted simultaneously and in the same field with the Red Spanish and Cabezona varieties, the commercial varieties of Porto Rico. As the latter have grown well and as Smooth Cayenne plants may be found in other parts of the island growing satisfactorily, a local unfavorable condition is probably responsible for the poor growth of this variety.

Algaroba (*Prosopis juliflora*).—Seed of this tree was imported from the Hawaiian Islands a number of years ago and plants distributed to many parts of the island. In the southern part of the island, where the rainfall is light and the soil contains considerable sand, the trees have grown well and produced good crops of seed

[1] Porto Rico Sta. Bul. 20 (1916).

FIG. 1.—TOTAFARI MANGO.

FIG. 2.—ALPHONSE MANGO.

FIG. 1.—ROBUSTA COFFEE IN FLOWER.

FIG. 2.—ROBUSTA COFFEE IN FRUIT.

in a few years after planting. In the locality of Mayaguez, where the soil is very heavy, the growth has been unsatisfactory. As this is a good shade tree, graceful in appearance, and producing seed pods which make valuable stock feed, it should be tested in all parts of the island.

Canavali incurva (S. P. I. No. 19990).—This canavalia, which is cultivated as a vegetable in a number of Asiatic countries, has been planted at three different seasons during the past year, but its growth has been poor as compared with that of brown and purple seeded types of *C. gladiata* or white-seeded *C. ensiformis* commonly grown here, and it has not been prolific. When the half-grown green pods are prepared as string beans, they have a pleasant flavor and are of good texture, but if allowed to get too large or old, they become very fibrous and an unpleasant flavor develops. Pods only one-fourth grown or less have little flavor.

Botor tetragonoloba (S. P. I. No. 37699).—This bean from the Philippine Islands was sent to Porto Rico in 1914 by the Bureau of Plant Industry, United States Department of Agriculture, and has been very thrifty and prolific. The seed pods when from one-half to two-thirds grown may be eaten as string beans. They are tender and of good flavor, though not so rich as many common garden varieties of beans. The climbing vines have a long growing season, bear large leaves and large showy blossoms, and are suitable for growing around verandas for protection from wind or light.

The results of a winter and a spring planting of a cowpea introduced from India indicate that it is well suited to conditions here. It makes a much heavier plant growth and has a longer growing season than the types usually grown in Porto Rico, and is, therefore, more valuable as a soiling or cover crop. It vines considerably, but not enough to be objectionable in orchards. It is being distributed to planters in different parts of the island for testing.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

Each year shows an increase in the number of coffee varieties in the station plantings. These are frequently sent to the station as selections from valuable varieties grown elsewhere or are received in answer to requests made to meet special needs. This work will doubtless ultimately prove of prime importance, since the present Porto Rican coffee is the result of years of unselected plantings of the same variety, which is forced to grow under widely varying conditions of soil and climate. Some of the introduced coffees already indicate greater adaptability to certain local conditions than the variety now grown. Additions this year include Bourbon, Quillou, several new strains of Robusta (Pl. II, figs. 1 and 2), and seeds from selected individuals. Seeds of promising varieties have been widely distributed.

In continuation of experiments begun some years ago as to the advantage of transplanting coffee from the nursery to the permanent location with the roots incased in a large ball of earth from the nursery, a much more extensive planting was made in August, 1914, more than 300 trees being included in the experiment. In the first 6 months the trees transplanted with roots incased in earth showed more than three times as great an increase in growth as that made by those transplanted with roots bare of earth. For the whole year the growth made by the former more than doubled that made by the latter. A year from transplanting nearly 34 per cent of the former and less than 2 per cent of the latter were producing coffee. These results serve to confirm the conclusions reached in the earlier test.

One fertilizer experiment with coffee trees planted in flat cane land to secure soil uniformity had to be discontinued on account of poor drainage. The other experiments have all been continued. As heretofore, large increases in yield have been obtained as a result of fertilizing.

In pot fertilizer experiments, the need of nitrogen has been clearly demonstrated. Tests were made using red-clay soil to which nitrogen, phosphoric acid, and potash were applied singly, in com-

binations of two, and the three together. The growth and general appearance of the plants placed them clearly in two groups, one including those plants to which nitrogen had been applied singly or in combination with acid phosphate, potash, or both, and the other of the check plants and those which had received either acid phosphate, potash, or both, but no nitrogen. When the first application of fertilizer was made, the average height of the seedlings of each group was 5.5 inches. At the end of a year the former averaged 40.3 inches in height and the latter 34.2 inches, which also was the exact height of the check. The leaves of the plants which had received nitrogen were dark green, in marked contrast with the yellowish green of those to which nitrogen had not been applied. As the amount of the coffee yield is dependent on the growth made by the plant, the new growth producing the crop, a profitable fertilizer for coffee must be one which produces growth. Nitrogen has been clearly shown to be the element which is most needed for this result on soil similar to that at the station. The pot experiments demonstrated that a need for this element might be indicated by a yellowish-green rather than by a dark-green leaf color.

Measurements of leaf lengths showed that the difference in this particular between the check pots and any other lot was well within the limits of experimental error. However, the nitrogen showed a very marked effect on number of leaves, the check pots having produced an average of 102.3 leaves per plant, those which had received no nitrogen but had received other fertilizer averaged 102.6 leaves per plant, while those which had received nitrogen averaged 117.8 leaves per plant.

As ammonium sulphate was the nitrogen carrier in these tests, it was thought desirable to start a new series comparing sodium nitrate with ammonium sulphate. At the same time another series of pot experiments was started to test under controlled conditions the effect of lime on coffee planted in the red-clay soil.

Some of the trees commonly used for shading coffee harbor injurious insects. Trees not used hitherto in Porto Rico as coffee shade trees are being tested and their development watched in order to find, if possible, some which may profitably supplant in certain localities the trees at present used.

In last year's report a coffee tree was mentioned some limbs of which bore variegated foliage and others only green leaves. Seed from this tree was again planted. Of the seedlings from the variegated limbs 47 had variegated cotyledons and 73 had normally colored cotyledons. From the limbs with green leaves all seedlings, 106, had normal green cotyledons.

CACAO.

In the work with cacao the individual yields of more than 300 trees are being recorded. These records have now been kept a sufficient time to show the prolific tendencies of certain individuals. Pickings are made every 4 to 6 weeks. The maximum yield recorded from a single tree at a single picking has been 54 pods. For the calendar year 1914 about one-fourth of the trees which were set 11 years before produced no crop. The others averaged 17.5 pods, or a gross return of about 22 cents per tree.

From one of the most vigorous and prolific trees a planting of nearly 100 seedlings has been made in order to study the differences to be found in seedlings derived from the same tree.

The color of the bean of *Theobroma cacao* and *T. pentagona* is supposed to indicate the quality. In a single pod from some trees the beans frequently range in color from light to dark. This coloring is still evident in the cotyledons for a considerable time after germination. Separate plantings have been made of seedlings from the same parent tree carrying light and dark cotyledons to see if this cotyledon color bears any relation to the character of the produce of the future tree.

VANILLA.

Efforts are being made to raise some hybrid vanillas, but up to the present no plants have been obtained from seed.

Some very interesting results have been obtained relative to the desirable length for vanilla cuttings, the plants always being propagated by cuttings. Five series were made, each of 16 cuttings, with 4 each of 2, 4, 8, and 12 internodal lengths. At three months only 3 of the 20 shortest cuttings had started growth of vine, while 10 of the next length, 11 of the next, and 16 of the longest had started growth. This new growth measured 9, 30, 52, and 148 inches, respectively, as the total for each length. At 6 months four of the shortest and one each of the next two lengths had failed to put out new growth, while all of the longest had started growth at less than 4 months. The new growth measured at this time 184 inches for the shortest cuttings, 358 inches for the next length, 710 inches for the next, and 1,261 inches for the longest cuttings. This showed unquestionably that with cuttings up to those of 12 internodes every advantage lies with the longest cuttings.

Vanilla is said to be a lime lover. To test this previous to starting cuttings air-slaked lime was supplied to four beds at the rate of 1, 2, 4, and 8 tons per acre. Four months later the bed which had received the heaviest application of lime showed a decidedly retarded growth. At 7 months the growth of vines in the bed which

had received lime at the rate of only 1 ton per acre had nearly doubled that of those in the most heavily limed bed and somewhat exceeded the growth in the check, which in turn slightly exceeded that of the two other beds.

In the vanillery nearly all of the 3-year-old vines of *Vanilla planifolia* blossomed, averaging about 10 inflorescences each. A fine crop was developed, which will be cured and marketed to furnish an indication of the value of vanilla grown in Porto Rico.

REPORT OF THE PLANT PATHOLOGIST.

By E. W. Brandes.

EXPERIMENTS IN THE CONTROL OF A BANANA DISEASE.

In another portion of this report an account is given of a banana disease investigated by the former plant pathologist of the station (see p. 36). The soil-sterilization and soil-inoculation experiments described therein have been repeated on a considerably larger scale and by the use of slightly different methods.

In order to have the plants attain full maturity, in a field adjacent to the banana plantation 30 large cylindrical cement tiles, 3 feet in diameter (inside measurement) and 4 feet deep, were sunk in the ground, with the rim projecting 4 inches above the surface, and filled with equal parts of red soil and river sand. The soil in 20 of these cylinders was sterilized with steam generated by a 2-horsepower boiler, the steam passing into the soil by means of a 7-ply steam hose leading to a ramification of perforated pipes driven into the soil to a depth of 30 inches. Steam was passed into these pipes under 60 pounds pressure and allowed to escape into the soil, all parts of which reached a temperature of 110° C. in about half an hour. This temperature was maintained for 1 hour, and the pipes then withdrawn by means of hooks sterilized with carbolineum. The tops of the cylinders were then covered with disks of tar paper soaked in carbolineum and weighted down with stones. Cylinders 1 to 10 were kept sterile by the employment of sanitary precautions, while Nos. 11 to 20 were inoculated with pure cultures of the Fusarium constantly associated with the disease and repeatedly isolated from diseased plants.

It must be admitted here that, owing to the prevalence of the disease on the western end of the island, obtaining absolutely healthy plants for experimental work is difficult, and that the association of the fungus and the disease has not been established satisfactorily by means of Koch's rules of proof, because a large percentage of the control plants develop the disease. Chamaluco suckers were recently received from Naguabo, on the eastern end of the island, which had every appearance of being healthy and from which no Fusarium or other parasite could be isolated. These plants were used in the

above experiment, 10 being planted in the 10 sterile cylinders, 10 in the inoculated ones, 10 in the untreated ones, and 10 additional checks in the banana plantation. The first-mentioned 20 plants, besides the disks of tar paper, were protected with wire-net cages, fitting closely to the projecting rim of the cement cylinders, to prevent injury or contamination from insects or small animals.

At the present time, 2 months after the experiment was started, all the plants are making a strong growth, none of them showing any indication of disease. It requires about 18 months for this variety to mature, and external symptoms of the disease do not appear until the plant approaches maturity.

MISCELLANEOUS EXPERIMENTS.

Various spraying experiments have been started to determine the practicability of controlling *Stilbella flavida*, causing a leaf spot of coffee, an undetermined leaf spot of vanilla, and *Pellicularia* sp. on the mangosteen. The latter, which is probably *P. koleroga*, has not been heretofore reported on this host.

A PORTO RICAN DISEASE OF BANANAS.

By G. L. Fawcett.[1]

In Porto Rico the variety of banana known as chamaluco or búlico, which belongs to the plantain group, *Musa paradisiaca*, is very subject to a disease which closely resembles that described as the Panama disease. Its activity does not become apparent in new plantings until the end of the second year, when a few of the shoots that make up each plant have fruited. Then it will be noticed that the petioles of the lower leaves, which are never so dark a green as in some other varieties, have become yellow. Later these leaves die, the dried hanging leaves being one of the most common indications of the disease (Pl. III, fig. 1). If flowering stalks are produced on the diseased plants, these are usually small, the fruits remaining half developed. The most characteristic feature of the disease is noticed on cutting open the bulb-like bases of the diseased shoots, where the diseased tissue has become red or yellowish in color, the still healthy part remaining white. The discoloration will often be found to extend down to one or more decayed roots, which is to be taken as indicating that through these roots the disease found entrance (Pl. III, fig. 2). Sometimes, also, there will be found a continuity of diseased tissue with that of the older shoots, showing that the disease is not always the result of a new infection. The leaves, owing to the injury to the roots and the fibrovascular bundles, are cut off from the source of food material to be obtained from the soil and die in consequence. It is not believed that the various organisms attacking the leaves and apparently causing their destruction are other than secondary.

The chamaluco is really an important plant, its fruit forming a considerable part of the food supply of many of the people. It is preferred to the fruit of others of the plantains, and if it could be cultivated more successfully would be one of the most important economic plants. For this reason the disease has been given much attention, having been studied with the purpose of determining, if possible, the nature of the organism causing the trouble, and also of finding whether, by certain methods of cultivation, the loss could not be lessened.

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[1] On leave from Feb. 6, 1915; resigned Feb. 6, 1916.

FIG. 1.—CHAMALUCO BANANA IN LAST STAGES OF DISEASE.

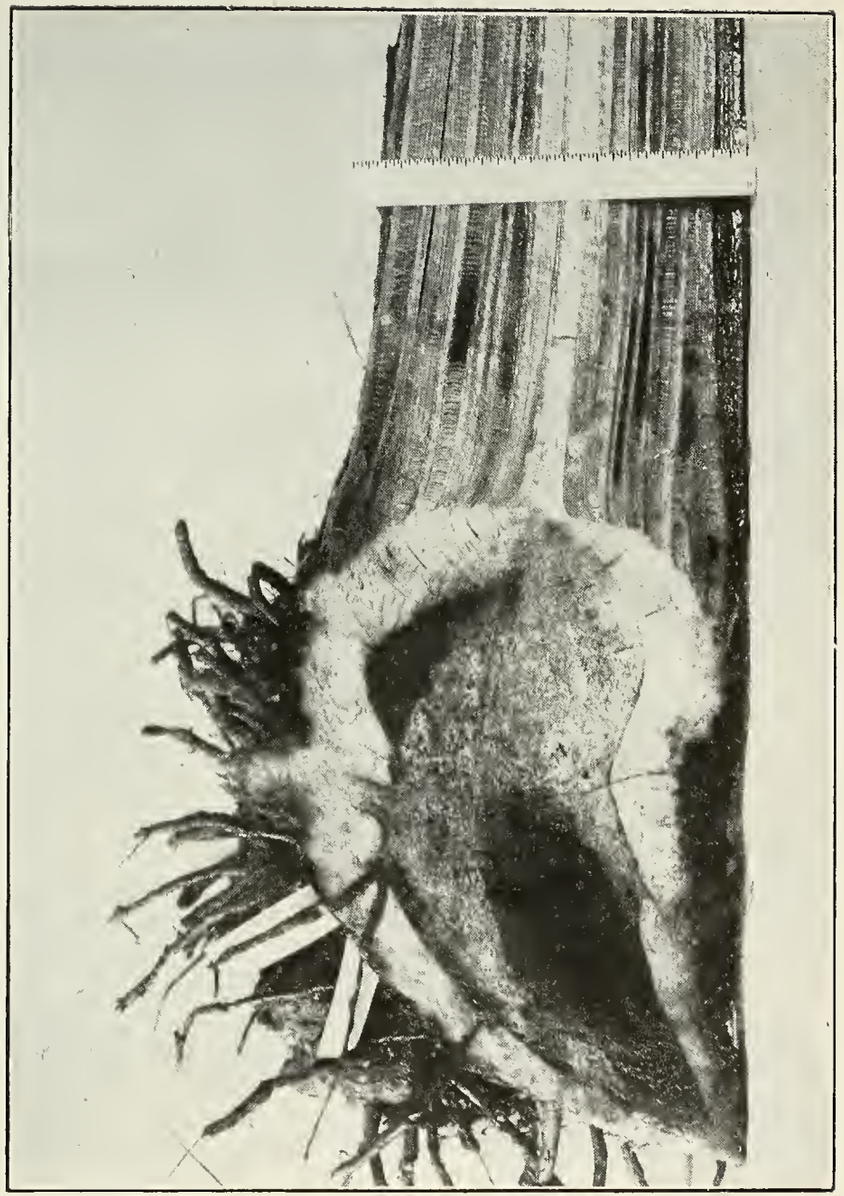

FIG. 2.—SECTION OF BANANA TRUNK SHOWING DISEASED AREAS.

As the use of disease-free "seed" or suckers in planting seemed to offer a practicable means of avoiding, at least temporarily, the bad effects of the disease, a field experiment for testing the use of such seed was begun. For planting, suckers as free as possible from the discoloration were selected, the surface when cut from the mother plant being white, and any injured roots were removed. An equal number of ordinary, slightly diseased suckers were also planted, the two plantings being separated by a ditch. The results of this experiment were as follows:

Comparison of yield from good and poor suckers.

	Poor suckers.	Good suckers.
Number of plants in plats	27	35
Yield (bunches), 1911–1913	27	52
Average yield, 1911–1913	1	1.5
Yield, 1913–1915	9	5
Total yield, 1911–1915	36	57
Average yield for entire period	1.3	1.6

In this experiment the treatment of the two plats was alike as to cultivation, no special effort being made to keep them free from diseased material. The results are not favorable to plant selection, except for the first two years of the experiment. The returns from the selected "seed" for that period were larger than those ordinarily obtained. If it is found by further tests that a decided improvement as to yield results even for the first two years, it would be advisable to use care in selecting the material for planting. That the yield of the last two years was not better is due to the equal abundance of the disease in both plats toward the last. It is clear, however, that disease-free "seed" can give but temporary relief. Although the ground used had not been planted before with bananas, so far as was known, the disease-producing organisms were in the soil as indicated by discolored areas extending down to diseased roots. For this reason it is believed that the principal infection came through the roots rather than from the mother plant, although there is some chance that, in spite of the precautions taken, the seed may have been already infested in some instances. Occasionally, apparently sound suckers with only slightly discolored threads on the cut surface are infected with bacteria, as was found later in selecting seed for inoculation experiments. One of these was used in a soil-inoculation test, and this and another one in direct inoculation into healthy tissues. No proof of parasitism was found, but if such exists and the suckers were already diseased, it is clear that to secure entirely sound plants is difficult.

It is the usual practice in Porto Rico to cut off at some 4 or 5 feet above the ground any shoots that have fruited, leaving the stumps to decay. As it seemed possible that the disease might begin in this

material and spread to any younger shoots with which it was in contact, especially as it was found to contain the Fusarium associated with the disease, it was thought that by prompt removal of the shoots that had fruited, the appearance of the disease could be at least retarded. For this purpose two plats of 25 plants each from good, though in some instances slightly infected, suckers were planted, one being left as a check plat, while from the other all the shoots that had fruited and also any others showing signs of the disease were removed. At the end of two years, the yield from the plat receiving the treatment was 25 bunches or 1 bunch per plant, that of the other plat being 35 or 1.4 bunches per plant. The results are thus hardly favorable to the use of sanitary measures.

In the diseased tissues there is always to be found a fungus, a species of Fusarium, the spores of which are 22 to 34 microns long by 4 to 6 microns wide, and the microconidia 5 to 7 microns long by 3 to 4 microns wide. In cultures on rice, the mass of mycelium is at first white, soon becoming pink. When left for several weeks it turns dark blue. In general characteristics, it agrees with Ashby's Fusarium A, described in a paper[1] on the Panama disease. It is also much like that described by Drost[2] for the imperfect stage of *Leptospora musæ*, but the identity of the two is improbable, since no evidences of a perfect stage were ever found, either on the plants themselves or in the cultures, although care was taken to secure the conditions said to favor its development.

Various bacteria occur in the diseased tissues. Inoculations were made with these at various times directly into the bulbs of healthy plants, but no evidence of parasitism was noted. The one chosen for the soil experiment was isolated repeatedly from reddened fibrovascular bundles penetrating well into the healthy tissues, where it often occurred in pure cultures. It forms circular, convex, opalescent colonies rapidly developing on synthetic asparagin glucose agar. A more detailed study of its characteristics was deferred until some evidence as to its parasitism could be secured, cultures being kept for this purpose. In the infection experiments the work was carried on along practically the same lines as those followed by Drost in his work with the Panama disease. That the results were not so convincing as those obtained by him may be taken as evidence that the Porto Rican disease and that of Surinam are somewhat different, the difference being made more probable by the fact that the varieties of banana are different, the Chamaluco being distinct from the Gros Michel, which is the variety subject to this disease in Surinam and Panama, the Gros Michel being unaffected by the disease in Porto Rico. The work was done as carefully as possible,

[1] Bul. Dept. Agr. Jamaica, 2 (1913), No. 6, p. 95.
[2] Dept. Landb. Suriname Bul. 26 (1912).

the soil being sterilized for several hours by dry heat, this reaching 155° to 160° during the last two hours. That it was effective was shown by testing some of the soil for the Fusarium and bacteria which had been inoculated with these previous to sterilization. The tests invariably failed to indicate the presence of these or other organisms. The shoots to be planted were disinfected with a 2 per cent copper sulphate solution and washed with distilled water. In selecting the shoots, all those with any diseased roots or other evidence of disease were rejected, the soil was inoculated several weeks before the shoots were planted, the fungus having been accustomed to growth in soil by the addition from time to time of sterilized soil to the plates in which it was cultivated in pure cultures. In the inoculation of the soil with the bacteria, liquid cultures were added to the freshly sterilized soil. In both fungus and bacterial inoculations the soil was moistened with distilled water before adding the organisms. In addition to this, a quantity of a pure culture was placed in contact with a freshly cut part of the bulb at the time of planting. After five months, during which the plants were watered with boiled or distilled water, they were removed and examined.

The first series of the infection experiments with the Fusarium consisted of five plants in inoculated soil and two in uninoculated soil as checks, the soil in every case having been sterilized as described above previous to inoculation. The results in this case were negative, as both of the check plants and one of the inoculated ones died soon after the experiment was begun. The death of these checks was probably due to their having been left for a somewhat longer period in the copper sulphate disinfecting solution, the subsequent washing with distilled water possibly not having been sufficient to remove all the copper. The others were typically affected with the disease, the Fusarium being present in the tissues. In a second series with Fusarium, consisting of four inoculated plants and three check plants, one each of the inoculated plants and the checks died soon after starting the experiment. Of the remaining plants, the checks were in excellent condition, while the inoculated ones were badly diseased, the sheaths showing pronounced decay. On examining the bases of the trunks, the checks showed only slightly reddened fibers, whereas the inoculated plants possessed every usual indication of the disease. However, cultures from the diseased tissue showed the Fusarium in the discolored fibers of one of the check plants as well as in those of the inoculated ones.

In the infection experiments with the bacteria in which the organisms already mentioned were used, the procedure was in all respects the same as in the infections with the fungus. Three check plants and five inoculated ones were used. None of the plants died. Both inoculations and checks varied markedly, some plants being healthy

in appearance, the others diseased. Unlike the inoculations with Fusarium, no decayed area characteristic of the disease appeared on any of the plants. The reddened fibers were abundant in all. Isolation cultures gave nothing in one of the check plants, and in the others a Fusarium identical with that of the typical form of the disease. The bacteria were isolated from one of the check plants and from all of the inoculated ones, healthy as well as diseased.

Perennial herbaceous plants, like the banana, are especially exposed to infection from the soil, owing to the absence of woody or other protective tissue at places of contact with the soil. It is indeed surprising that the Chamaluco is the only variety suffering from the disease. Several other varieties were examined, specimens being selected at various stages of development. In some of these, bacteria were found well within the center of the trunk. Decayed roots and areas of decay near the surface were common, but neither the typical marks of the disease nor the accompanying Fusarium were discovered.

The decaying leaf sheaths of the older leaves become infected with various bacteria and fungi. That these are saprophytes merely is indicated by their being unable to produce decay in healthy sheaths when inoculated from pure cultures. Similar results were obtained with those isolated from the diseased bulbs and inoculated into leaf sheaths, decay resulting in no instance. When introduced into healthy material from the trunk and kept in a moist chamber, the usual precautions to secure sterile conditions being observed, no decay typical of the disease developed, the nearest approach to such decay being that resulting from the Fusarium. The living tissue is quite resistant to such attacks, although unfortunately not enough so to prevent the disease.

Conclusive results were not obtained from the infection experiments, although they tend to show some degree of pathogenicity for the Fusarium, plants inoculated with this fungus more often becoming diseased than check plants or those inoculated with bacteria. The disease, which is clearly due to parasitic organisms, is slow in action, several months being required to affect the health of the plants. Slight infection is common in apparently healthy young plants.

The condition of the experiments made it impossible to continue each test more than six months, the soil after that time not being sufficient for normal growth of the plants. A much longer period would be necessary to bring out fully the differences between infected and uninfected plants, requiring the sterilization of much larger quantities of soil, a slow procedure at best when carried out thoroughly. Other difficulties include outside infection of soil exposed to the air for the long periods required by slow growing, slow maturing of plants, and obtaining entirely disease-free shoots for planting.

Very healthy-looking ones were found by test cultures to contain the bacteria in the fibrovascular bundles well within the center of the plant. Very definite conclusions have been reached in work similarly conducted in the case of the Panama disease. It would seem, however, that results from work with plants lending themselves so unsatisfactorily to soil inoculation experiments should be given credence only after the work has been repeated and like results obtained by other workers.

To summarize, the results are such as to warrant the selection of healthy, vigorous shoots for planting and the use of fertilizers and cultivation in order that as many fruit-bearing shoots as possible may be produced in each clump before the disease can make enough progress to injure the plants seriously. Soil disinfection to a depth sufficient to be of value is impracticable. Such measures for controlling the disease as those reported used in Surinam and elsewhere with very favorable results are entirely without good effect in Porto Rico. Under present conditions there is little prospect that the Chamaluco can be regarded as more than a temporary crop, as two years from the time of planting it is invariably too much diseased to be of further use. The study of the disease has furnished no proof that it is due to a definite parasite, the Fusarium accompanying the disease answering only in part as its probable cause. It is, however, possible that even a slightly parasitic organism and one of slow growth could destroy the plant by invading the tissues in large numbers. The mass action of an abundant fungus or bacterial growth continued for several months is equivalent in effect to that of stronger parasites acting for a shorter time.

REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg.

The principal work of this department has been with the changa, the cattle tick, and various coffee insects. A bibliographical card index of Porto Rican entomology was obtained through the courtesy of the Insular Experiment Station at Rio Piedras, and has been kept up to date.

As usual, the principal sugar-cane pests were the white grub and the moth borer. The coffee weevil, the leaf-miner, and the hormiguilla were as serious pests of coffee as ever. Among garden insects the changa, the flea-beetle (*Systena basalis*) on beans, beets, and okra, and a tingitid on eggplant were very troublesome. The detailed work on the life history of the changa (*Scapteriscus didatylus*) is progressing well, and various remedial measures are being tested.

The cattle tick (*Margaropus annulatus australis*) is being studied with reference to working out a pasture-rotation method of extermination applicable to Porto Rico. The tick is undoubtedly a most serious drain on the island's prosperity, but there is no reason to believe that this pest can not be exterminated, although the time is perhaps not yet ripe for this work.

INSECTS ATTACKING COFFEE AND COFFEE SHADE.

Experiments were conducted with promising native trees in the hope of finding a tree which the hormiguilla (*Myrmelachista ambigua ramulorum*) can not colonize with guest scales, and which at the same time will provide satisfactory coffee shade. Twelve common native tree species were found to harbor thriving colonies, and no tree suitable for shading coffee was found in which the ants could not be forced to colonize. The pink scale (*Coccus* sp.) has not been found as the guest in ant colonies in coffee, aguacate, or guaraguao (*Guarea* sp.), only the mealy bug (*Pseudococcus* sp.) having been found attended by ants in these three trees. Colonies of the hormiguilla seem to thrive better and consequently to cause more damage when the pink scale is the guest than when the mealy bug alone is harbored.

Observations were made on the coffee leaf weevil (*Lachnopus* sp.), This insect is very destructive to coffee at the higher altitudes; it has not been observed at an elevation lower than 300 meters. The weevil is about one-fourth inch long, varying from "pepper and salt" to a

clay color. It produces a characteristic injury through feeding on the edges of young leaves, the blackened ragged edges becoming conspicuous after a few days. The greatest loss, however, is caused by feeding on flowers, young buds, and newly set berries which are to form the crop. The beetle is said to be most troublesome during the months of June, July, and August. Attempts to breed this insect in Mayaguez have been unsuccessful, owing possibly to climatic conditions. A cluster of 54 eggs was laid by an adult in captivity, but all failed to hatch. The eggs are laid in regular rows, being protected by gluing the leaves together. In some districts the weevil is the most serious pest of coffee, doing immense damage near Adjuntas.

GARDEN PESTS.

A very common weevil (*Baris torquatus*) was found breeding in the branches of eggplant, and in some cases it completely killed the plants. The weevil is about 5 millimeters long and strikingly marked with black and white. The adults are very common on berengena cimarrona (*Solanum torvum*), but the writer has not yet observed the young stages in anything but the eggplant. The white, oval egg is deposited within a crescentic slit cut in the stem. The larva is a legless grub about 7.5 millimeters long when full grown. All the developmental stages are passed within the stems of the plant, and as a result control is rather easy. As soon as a branch is found to be infested it should be removed and destroyed. The adults may be collected by hand and killed.

A lace-wing (*Corythaica monacha*) is very common on eggplant. It sucks the plant juice and dries out the leaves, causing them to curl and turn brown. The insects are most numerous on the under-leaf surface and on the topmost leaves of the plant. A 1:10 kerosene emulsion will keep the insect from becoming too troublesome.

WHITE ANTS OR COMEJENES.

There are two very common species of termites in Porto Rico. The one which makes the conspicuous brown runs on tree trunks and builds a papery, dark-brown nest, is *Eutermes morio*, and is the more common of the two. This species often makes its way into houses, doing great damage to furniture and woodwork. A very cheap and efficacious control of this pest is obtained by placing liberal quantities of any powdered arsenical poison in the runways and nest. The insects' habits insure the spread of the poison throughout the colony, and the nest is killed out completely in from one to three days. London purple gives quicker results than Paris green, probably because of the finer division of the particles.

The other species (probably *Leucotermes* sp.) establishes itself in woodwork and furniture, hollowing out irregular galleries with the grain of the wood and often leaving only a very thin partition to conceal the galleries from the outside. Often the first indication of infestation by this species is the presence of fine, granular droppings beneath the wood. Fumigation with hydrocyanic-acid gas is the surest way to control this insect, but stronger dosage and longer exposure than usual are necessary to insure penetration of the narrow galleries.

THE RHINOCEROS BEETLE OF COCONUTS.

Young coconut trees in Porto Rico are often killed by the work of an adult rhinoceros beetle (*Strategus quadrifoveatus*), which enters the nut below the surface of the ground and eats its way upward, attacking the main shoot. Such damage is most common during the rainy season. The adult is the only form causing any damage, since the larvæ feed only in dead wood, such as rotten coconut logs, where the egg is deposited by the adult. The larval period is long, probably requiring over a year for completion. If care is taken to have no logs lying about the grove, no breeding places will be left in the vicinity and the chances of attack by the adults will be lessened. Some coconut growers have trap heaps of decaying logs loosely covered with earth, which are inspected carefully about once in six months, all the larvæ found being destroyed.

MISCELLANEOUS PESTS.

A "round-headed borer" (*Apate francisca*) is very numerous about Mayaguez and during the past year has been repeatedly found boring in young mahogany trees. The young stages have been found only in dead trees, but the work of the adults so weakens the trees that they are easily broken in a heavy wind. Adults at work in a tree can be killed by running a stiff wire into the burrow. This insect also does considerable damage to coffee, citrus, and gandule, or pigeon peas.

Ornamental palms are sometimes disfigured by the work of a lepidopterous larva on the under leaf surface. The small greenish larva works within a loose, frass-covered web, eating the parenchyma.

A noctuid larva (probably *Eriopus floridensis*) is not uncommon on the fronds of ornamental ferns. It is easily overlooked because its color almost exactly resembles that of the plants upon which it rests. In the United States hand picking has been recommended to control this insect.

Coconut trees, especially in the dry region in the southwest corner of the island, are often seriously injured by *Aspidiotus destructor*. Parasitic and predacious enemies do not seem to hold this scale in check. An oil spray is practical in the case of young trees whose leaves can be easily reached. With large trees it will sometimes pay to remove and destroy the leaves most heavily infested.

A very small, dark, long-snouted weevil was found breeding in the flower buds of eggplant. Two or three larvæ are usually found in a single bud. The infested buds dry out, droop, and drop when touched. It is probable that this obscure insect does considerable damage.

Sipha flava, the yellow aphid of sugar cane, was noticed to be very numerous in small areas near Mayaguez. Predacious enemies can usually be depended upon to reduce the number of aphids before serious damage is done, and artificial remedial measures are seldom necessary.

Oleanders are often attacked by a conspicuous orange caterpillar marked with silvery stripes, the larva of *Empyreuma lichas*. The round, yellow eggs are laid on the under side of the leaf in groups, the individual eggs being very regularly spaced one from the other. They have a dull sheen, are slightly iridescent, and under the lens are sculptured with fine reticulate markings. They change to light brown just before hatching. The larvæ average about 26 days from the egg to the pupa, and about 13 days more are spent in the pupal stage. The adult is a striking moth, with crimson wings and a dark-blue body. Hand picking the larvæ will give relief from the pest, which is seldom very numerous on any one plant.

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